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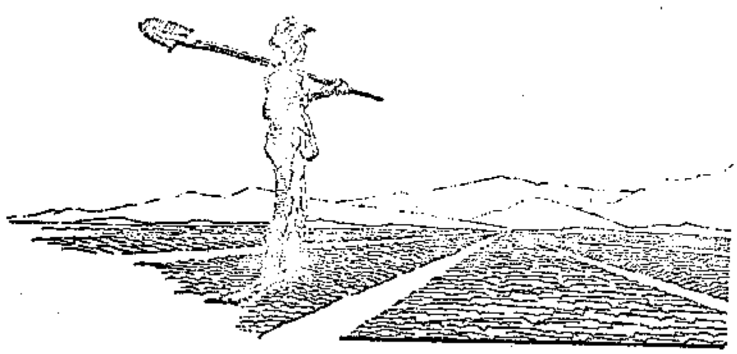
PROCEEDINGS



Oregon Reclamation Congress

IMPROVED SEEPAGE METER OPERATION FOR LOCATING AREAS OF HIGH WATER LOSS IN CANALS AND PONDS

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INTRODUCTION

A seepage meter consists of a bell or chamber which is placed in the bottom of a canal to measure the rate of water loss at that point. Seepage meters have been studied for over twenty years in the Western United States with variable results (4, 5, 8), but these meters are capable of locating areas of high water loss and they permit economical testing of the canals at any time during the operating season. These advantages are sufficient to merit further effort to overcome the problem of point-to-point variability of the measurements.

This paper describes a meter that has been designed at the Snake River Conservation Research Center for making rapid seepage measurements in operating canals and ponds. It also presents some comparative results between the meter measurements and laboratory tests and field ponding tests. The meter permits averaging many readings to obtain a seepage value that is usually within 10 to 50% of the value obtained with a ponding test. This accuracy is sufficient to estimate the value of a seepage control program.

EQUIPMENT DESCRIPTION

The meter incorporates three desirable features of two previous models, the "Tempe Seepage Meter" (1) and the "Weber Basin Seepage Meter" (3). These three features are: a "removable" cover, a manometer to show the pressure difference between the inside and the outside of the chamber, and a Mariotte-siphon reservoir water supply. These features and other innovations enable: (a) the meter to be placed in the canal bottom with a minimum of disturbance of the sediments, (b) the "sealed condition" to be tested, (c) the pressure difference between the inside of the bell and the surrounding water to be observed and minimized, (d) the seepage rate to be determined in a few minutes, (e) the unit to be easily moved from point to point while wading or when operated from a boat in deep water, and (f) measurements to be made well up the slope of canal or pond banks.

The seepage meter chamber consists of a base cylinder and a cover which can be opened or closed. The base cylinder is made from a 6-inch length of 12-inch-diameter light-wall steel pipe, sharpened on the lower edge (Figure 1). The cover is a 1/4-inch thick round aluminum plate with a rubber gasket seal between it and the base cylinder when the meter is operating. The cover is raised above the base cylinder or clamped tightly to it with a jacking screw which lifts or presses at the center of the plate. The clamping screw is turned by a long T-handle which extends above the surface of the water. The top of this handle is supported by a light steel frame which extends 4-1/2 feet above the seepage chamber. This length could be increased for operation in deeper water. The outer rods of the frame act as guides for two sliding drop hammers which are used to drive the base cylinder into firm soil.

A 3/8-inch-diameter plastic, inverted U-tube manometer, and two plastic Mariotte-siphon reservoirs are mounted on a small panel which is placed just above the water surface near the seepage chamber (Figures 1 and 2). One end of the U-tube manometer is connected to the top cover of the seepage chamber, and the other end is suspended in the water surrounding the chamber.

There are two Mariotte-siphon reservoirs which are made of clear plastic tubes 16 inches long, sealed at the ends with rubber stoppers. A 1/8-inch-diameter tube, cemented to the outside of each of these tubes, allows air to bubble in at about 1 inch above the bottom of the reservoir which is being used as the supply source for the seepage chamber. One is 1/2-inch-diameter reservoir that is used for measuring seepage rates of one cubic foot per square flot per day, or less. The other is a 1-1/2-inch-daimeter reservoir that is used for seepage rates greater than one cubic foot per square foot per day.

The manometer and the two reservoirs are equipped with millimeter scales to measure the water surface levels. The panel on which they are mounted can be adjusted vertically with either a coarse or a fine adjustment. The coarse adjustment is quickly made by means of a spring-loaded clamp that is moved up or down along a 1/2-inch-diameter steel rod that has been forced into the canal bottom, as shown in Figure 1. The fine adjustment is made with a friction wheel which can be rolled up or down along the rod to slightly raise or lower the reservoirs.

A 4-way selector valve is used to control the source of the water that is seeping out of the chamber when the "seal" is being tested, or when the seepage is being measured. Water can be drawn from the canal or pond, from either of the reservoirs, or the water supply may be turned off. The valve is mounted so that it is just below the water surface while a test is being made.

The flexible tubing connecting the reservoirs, valve, and the chamber is 9/16-inch-diameter vinyl tubing. The manometer connections are made with 5/16-inch-diameter vinyl tubing.

OPERATING PROCEDURE

The meter is operated in the following steps:

1. The seepage chamber is placed on the canal bottom either by wading or from a boat. While the cover is open, the chanber is forced into the soil slightly---just enough to get a seal.

2. The steel rod which supports the reservoir-manometer panel and the selector valve is forced into the soil nearby, so that it stands approximately vertical and is securely in place.

3. The tubes connecting the reservoirs, selector valve, and the seepage chamber are checked and any trapped air bubbles are removed. The manometer and its tubing are filled with water by applying suction to a fitting at the top of the inverted "U". The water surfaces in the two sides of the manometer are lowered to midscale by permitting air to enter the top of the "U". If the two water surfaces are not level with each other, the manometer must be drained and refilled to remove air bubbles trapped in the tubing. Small differences in the manometer levels may be caused by velocity effects. This is adjusted by shielding the intake port of the selector valve and the intake for the "free water" leg of the manometer.

4. The selector valve is turned so that water can flow from the canal (or pond) to the chamber. The cover is sealed to the base cylinder by turning the jack screw handle. As the seal is made, the manometer will register pressure surges of 2 to 5 cm of water. This is a first indication that the bottom edge of the base cylinder is sealed in the soil. These small surges are quickly relieved by flow from the chanber back to the canal through the selector valve.

5. A "seal test" is made next. The selector valve is turned to cut off all water supply to the chanber. If the system is properly sealed, the manometer will indicate a drecreasing pressure inside the chamber as compared to the pressure outside the chamber. The maximum amount of pressure difference will be the "balanced head" (2), or "zero seep" (6) value. This is the approximate pressure drop caused by water flowing through soil from the canal bottom to the bottom edge of the chamber. At low seepage rates, it may be a very small value. If this is the case, a better seal test may be made by introducing a low pressure inside the chamber. Under this condition, if the chamber is sealed in the soil and seepage is low, the pressure will dissipate slowly. If there is no seal, or it is weak, the pressure will dissipate slowly: If there is no seal, or it is weak, the pressure differential will rapidly decrease to zero and stay there. If there is no seal, the valve and top cover should be opened, and the meter driven further into the soil and then retested for a seal. If there is still no seal, the meter should be moved a few feet to another location to make the seepage measurement.

6. After the seal test is satisfactory, the selector valve is turned to connect one of the Mariotte reservoirs to the chamber. The manometer is now used to determine if the reservoir is at the proper elevation. If the manometer indicates a pressure in the chamber greater than that of the surrounding water, the reservoir must be lowered. If it indicates the pressure in the chamber is lower than that of the surrounding water, the reservoir must be raised. At low seepage rates, a short time is required to allow the manometer to come to equilibrium after each small adjustment of the reservoir elevation.

7. After the reservoir elevation is adjusted, the selector valve is again turned to connect the chanber to the water surround it. The initial water surface level in the reservoir is recorded as indicated on its millimeter scale. A stop watch is started as the selector valve is turned on to again connect the seepage chamber to the reservoir. The manometer is observed while the water is being supplied from the reservoir. If any slight pressure differential is noted, it may be removed by a fine adjustment of the reservoir elevation. The reservoir is used as a supply of water to the seepage chamber for 1/2 minutes for fast rates, 1 minute for medium rates, or 2 minutes for slow rates. The valve is then turned again to connect the chamber to the surrounding water, and the final level of the reservoir surface is recorded. The amount of drop in the reservoir surface and the time required for this drop are used with a chart (Figure 3) to determine the seepage rate.

8. After the test is completed, the cover is opened and the equipment can be moved to the next location. If the distance is small, the chamber and associated equipment can be moved without losing the "prime" of the manometer tubes or getting air in the seepage supply tubes by keeping the ends of these tubes submerged. This speeds up the procedure considerable.

9. The meter may be used to measure seepage from sloping banks by supporting the top of its framework ot prevent the chamber from falling away from the bank. This

is done by using a tie-back line or a brace rod which extends from the bottom of the canal to the top of the frame.

TEST RESULTS

The meter was initially tested in a 38-inch-diameter sand tank, which contained 28 inches of fine dune sand with a saturated hydraulic conductivity of 4.6 inches/hour. Water was ponded above this sand to a depth of 18 inches while two meters were operated side by side in the tank. The seepage rate through the tank was controlled by varying the elevation of the drain outlet. The rate was varied between 0.1 foot/day and 20 feet/day. A comparison of the seepage rates measured by the meters to the rate of seepage through the bank is shown in Figure 4.

The meters indicated a seepage rate about 11% higher than the tank outflow. The depth of insertion of the meter edge into the sand had no consistent effect on the readings of the seepage meters. The time lag between the insertion and the time readings were taken also had little effect on the seepage meter readings.

A ponding test was performed on a 1000-foot length of a small lateral of the Minidoka Irrigation District at Rupert, Idaho. This pond ad a seepage loss of 1.0 foot/day at operating level. After the water level dropped 0.8 foot, the rate decreased to 0.49 foot/day. An average of 35 seepage meter tests showed a loss of 0.33 foot/day at this depth. The average of 20 tests made along the center line indicated a seepage rate of 0.19 foot/day, and an average of the 15 tests made just above the inside toe of the bank indicated a seepage rate of 0.43 foot/day. The meter tests clearly located the areas of high loss as shown by Figure 5. These tests indicated that the banks were seeping at a higher rate than the bottom, and that if more of the tests had been made further up the tanks, the agreement between the meter and the ponding tests would have been closer.

A 2-1/2-acre pond near Caldwell, Idaho was tested in cooperation with the U. S. Bureau of Reclamation. The pond had been partially sealed with a roughly placed silt blanket. Seepage meter tests were made on a 50-foot grid pattern throughout the pond area when the water was about 3-1/2 feet deep. An average of 50 tests at 34 locations indicated a seepage loss of 0.10 foot/day, while a water level recorder showed the water surface was dropping at 0.18 foot/day. The greatest losses were in one corner of the pond, where losses of up to 0.6 foot/day were measured (Figure 6). This higher seepage area covered approximately 21% of the pond area. The meter indicated that the remainder of the pond had an average loss rate of less than 0.05 foot/day. The meter successfully located the area of greater loss so that it can receibe further treatment without sealing the whole pond. More concentrated testing of the high seepage area might have located small areas of very high loss.

TIME REQUIREMENTS

The time required for making seepage tests in a canal or pond depends on the following:

1. Rate of seepage. Seepage rates below about 0.2 foot/day require up to 1/2 hour for each test. An extra 10 to 20 minutes is needed for very carefully testing the seal and adjusting the reservoir elevation.

2. Distance moved between tests. When the meter is moved only a few feet, the system maintains its prime and a complete test can be made every 5 or 6 minutes if the seepage rate is 0.5 foot per day or more. Longer moves require 10 to 20 minutes per test.

3. Depth of water. Operation from a boat (in water 3-1/2 to 6 feet deep) requires additional time to maneuver the boat into position and then anchor or tie it in place. Tests spaced 100 feet apart along a canal flowing 3-1/2 feet deep have been made from a boat ar 15-minute intervals.

4. Flow conditions. In deep water with greater velocities, it is more difficult to place the meter and hold it in position. Readings have been taken in water 5 feet deep flowing at about 2 to 2-1/2 feet per second. Special techniques may permit use at somewhat higher velocities and depths, but this would require more time for each test.

5. Bottom conditions. When the bottom is gravelly, very hard, or has woody roots, it may be difficult to find a location where the bell will penetrate uniformly enough for an adequate seal. These conditions may require that the meter be moved about in search of a spot where it will operate. This may require an additional 10 to 15 minutes for each test.

An example of the recent use of a seepage metter to analyze the losses from an irrigation system is given in the Soil Conservation Service's "Seepage Meter Report" (7) to the Stanfield and Westland Irrigation Districts near Hermiston, Oregon. Two newly trained men working for four weeks made 400 tests at 109 cross sections along 28 miles of canals. This gave sufficient data to locate the canals and areas with the high loss rates and to make estimates of the daily quantity of water lost from certain parts of the system. The meter used was an earlier model that uses a "water bag" supply rather than a Mariotte-siphon reservoir. This later improved design permits even more tests per day.

The 35 wading tests made along 1000 feet of the lateral of the Minidoka Irrigation District required about 10 man-hours.

The fifty tests made in the 2-1/2-acre pond required about 48 man-hours to test from a boat, plus 8 man-hours to lay out the horizontal control points. The low seepage rates existing over most of the pond area increased the time required.

SUMMARY AND CONCLUSIONS

An improved seepage meter unit has been developed for use in operating canals and ponds. It has been designed for faster and more controlled operation than was possible with previous designs. The absolute value of the seepage rate obtained by averaging many seepage meter tests may not completely agree with the value obtained by ponding tests. Laboratory tests in a sand tank indicated the seepage meter gave values about 11% higher than the actual flow through the bank. When compared to two field ponding tests, the average obtained with seepage meter tests was 50% lower. This could have been caused by high loss rates in very small areas that were not tested. Further evaluations will be made to define the accuracy obtainable with seepage meters under field operating conditions.

A similar seepage meter was successfully used by the Stanfield and Westland Irrigation Districts in northereastern Oregon in a preliminary study to locate the areas of high loss in the systems and to estimate the magnitude of these losses.

This seepage meter design has the ability to make seepage tests considerably faster and easier than was possible with previous designs, thereby giving a more representative average value. The accuracy of this value is sufficient for use in making practical estimates of seepage losses from various parts of an irrigation system.

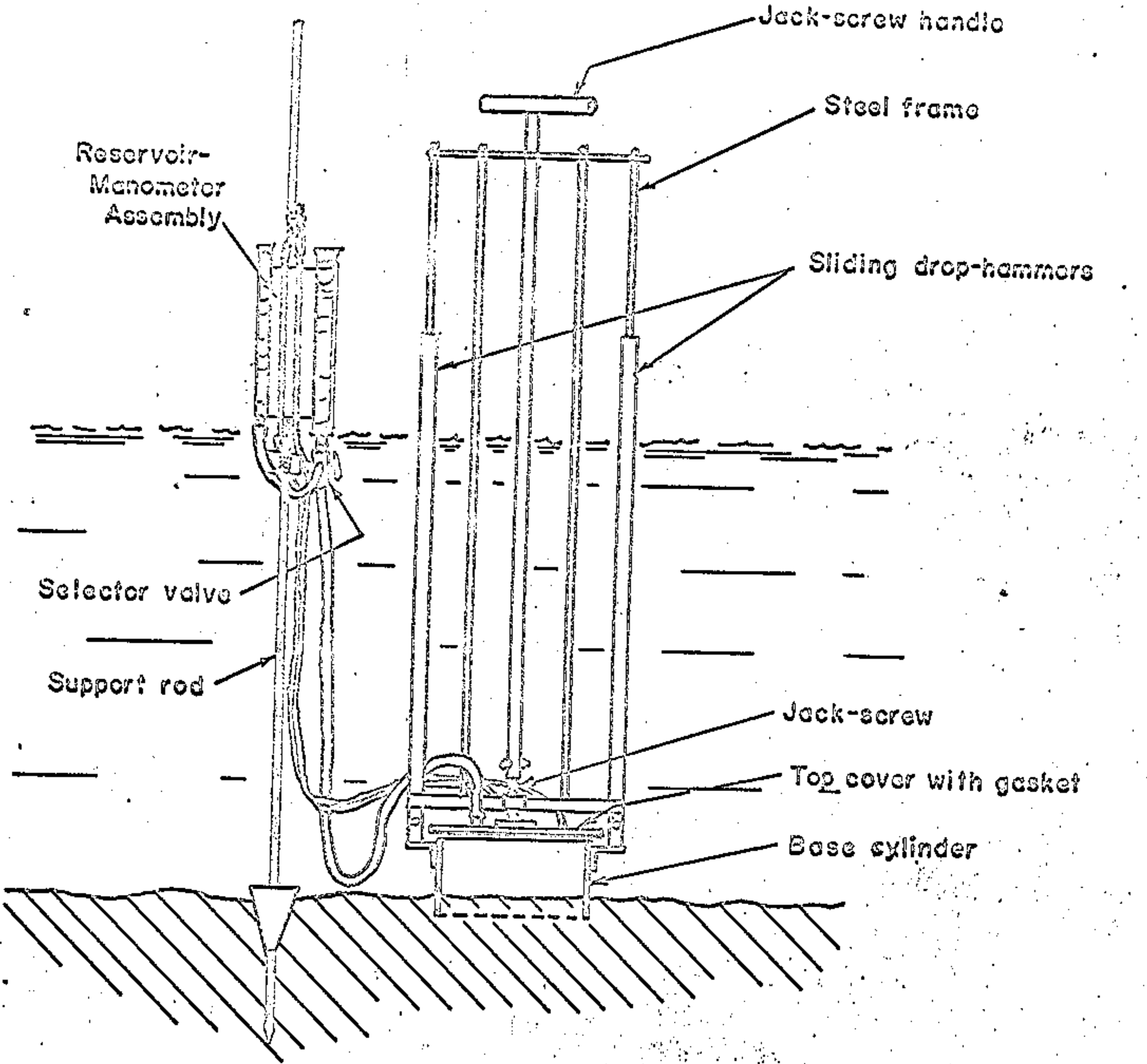

Figure 1. Overall view of seepage meter equipment

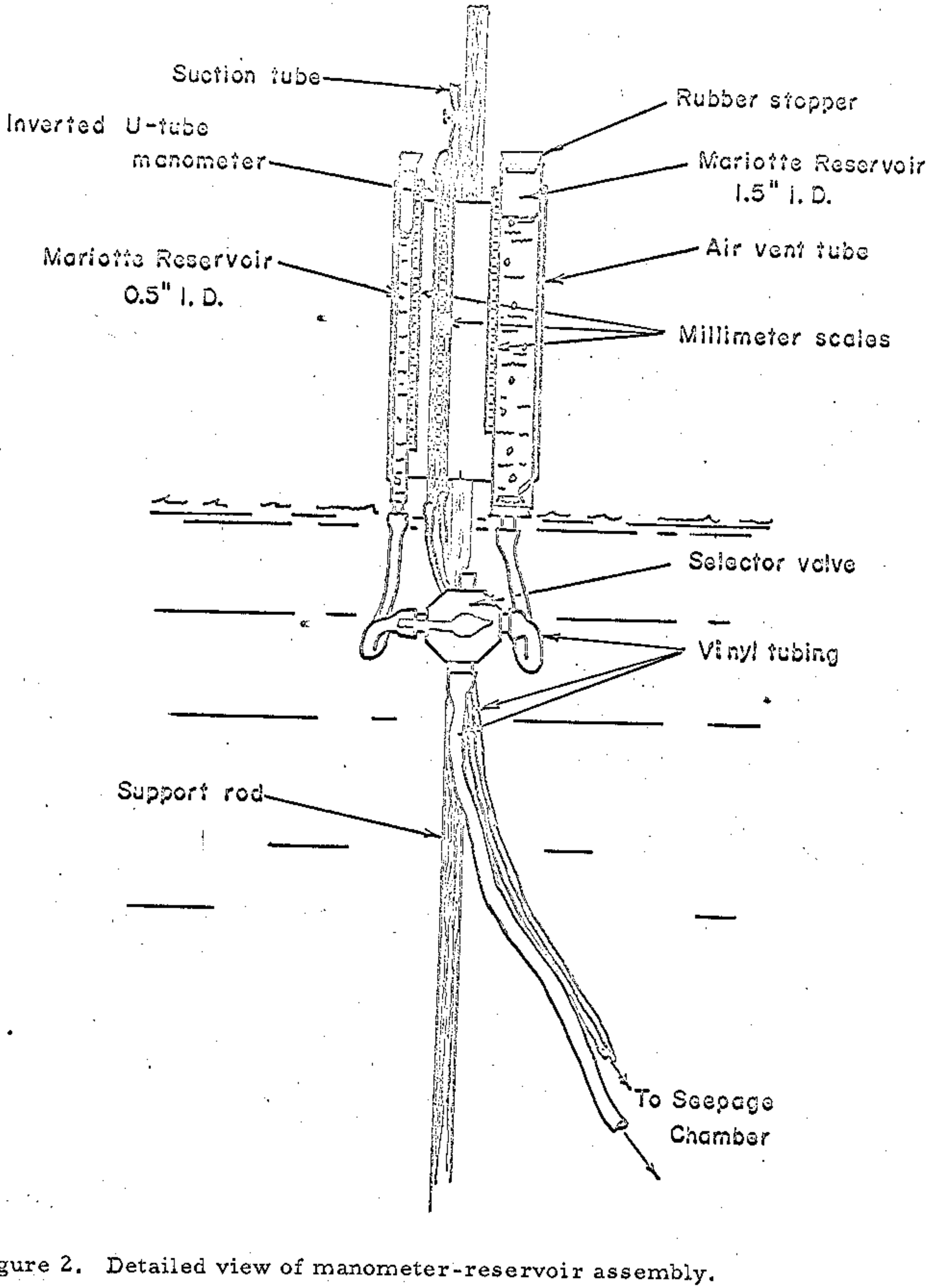

Figure 2. Detailed view of manometer-reservoir assembly.

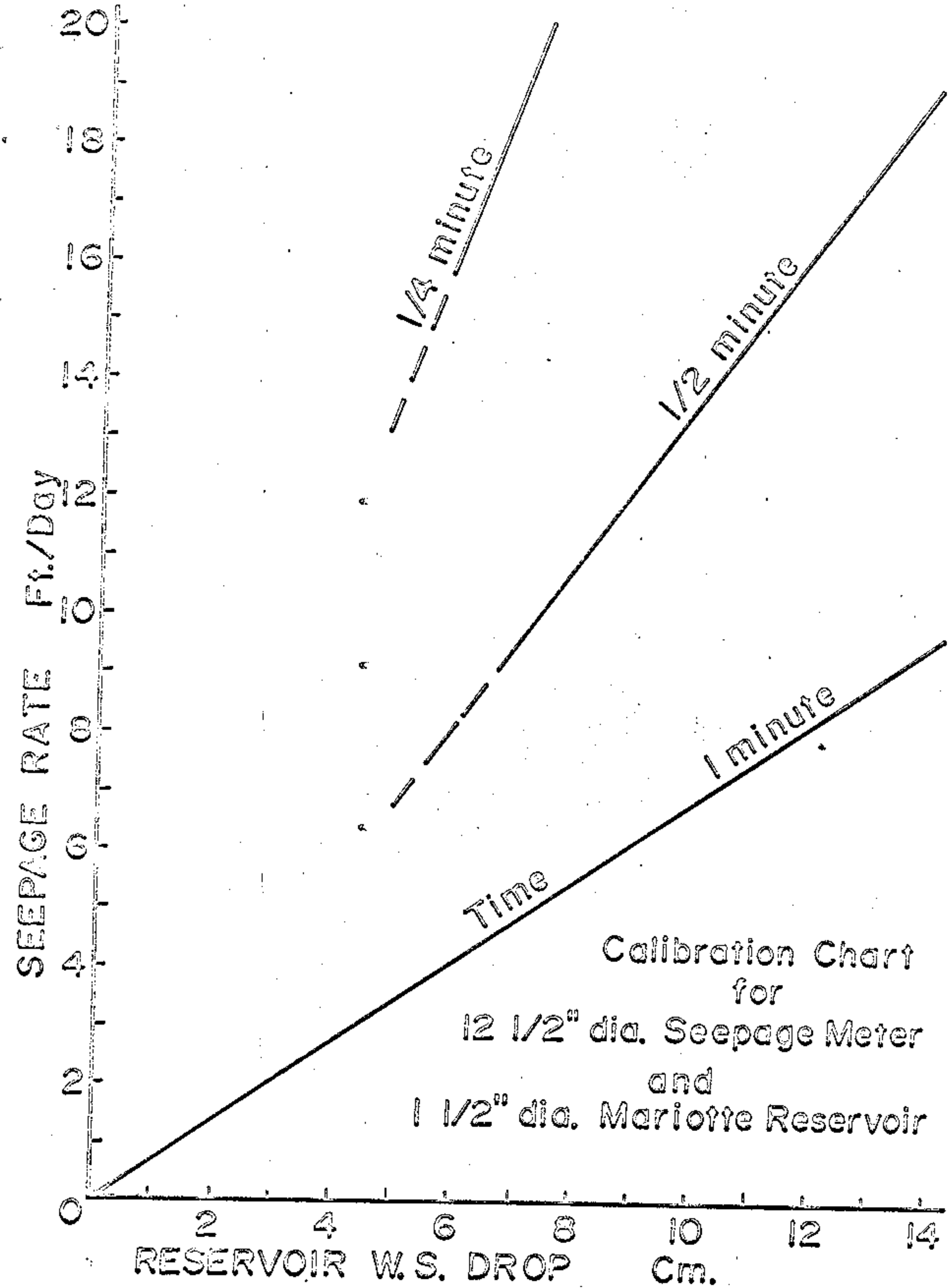

Figure 3. Seepage rate chart.

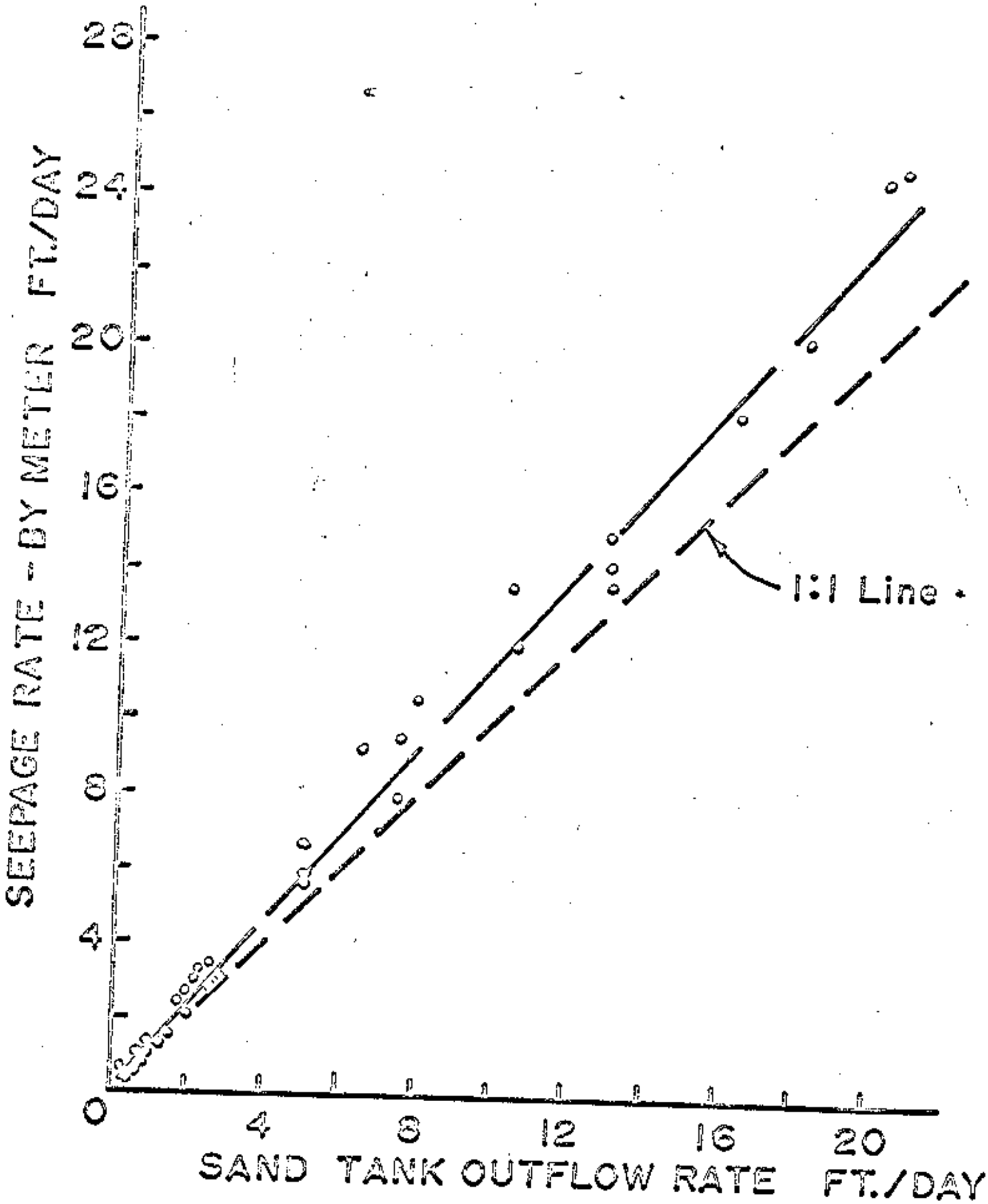

Figure 4. Comparison of sand tank outflow rates and seepage meter measurements.

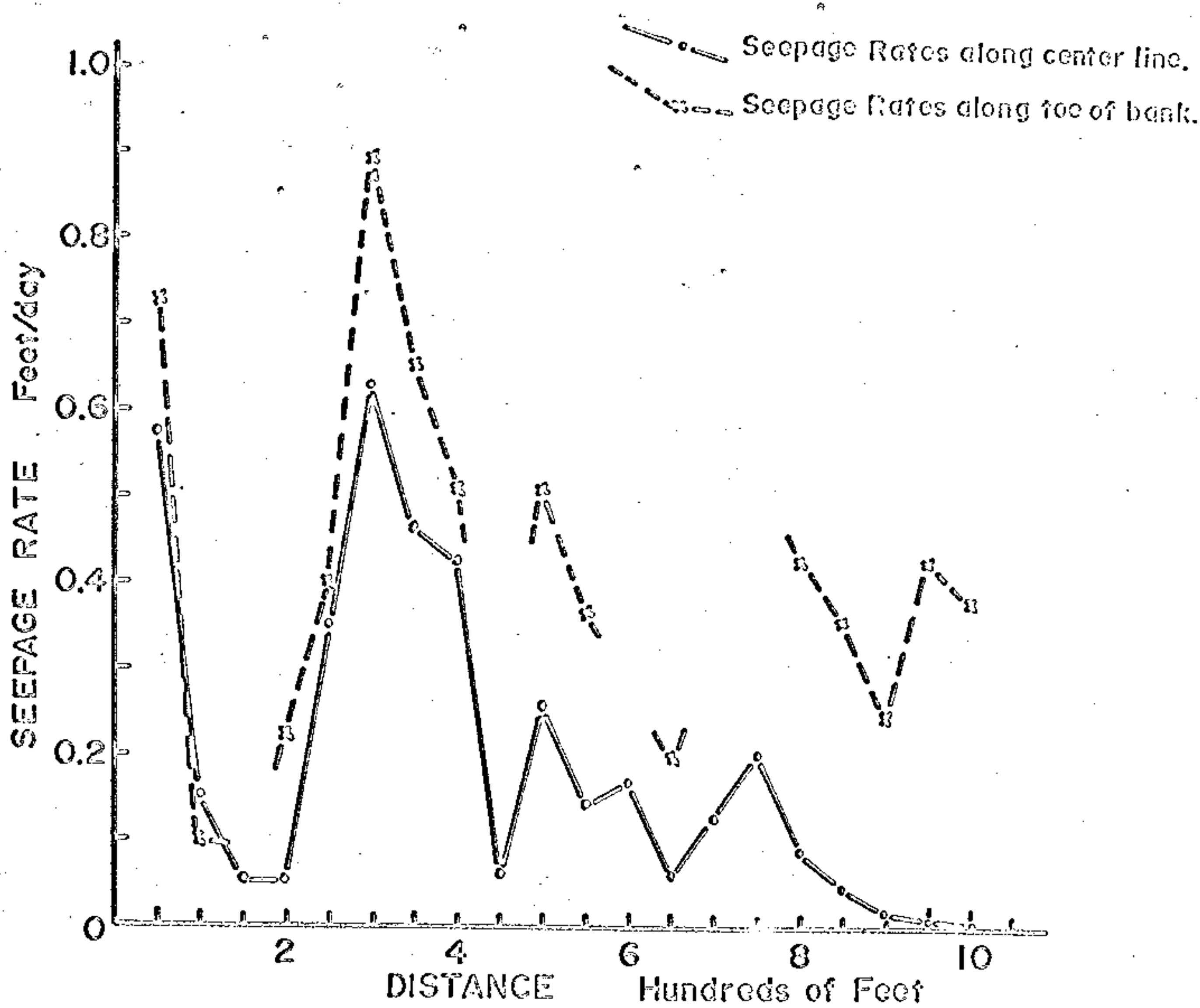

Figure 5. Seepage rate distribution along the lower end of #1011 lateral of the Minidoka Irrigation District in August, 1969.

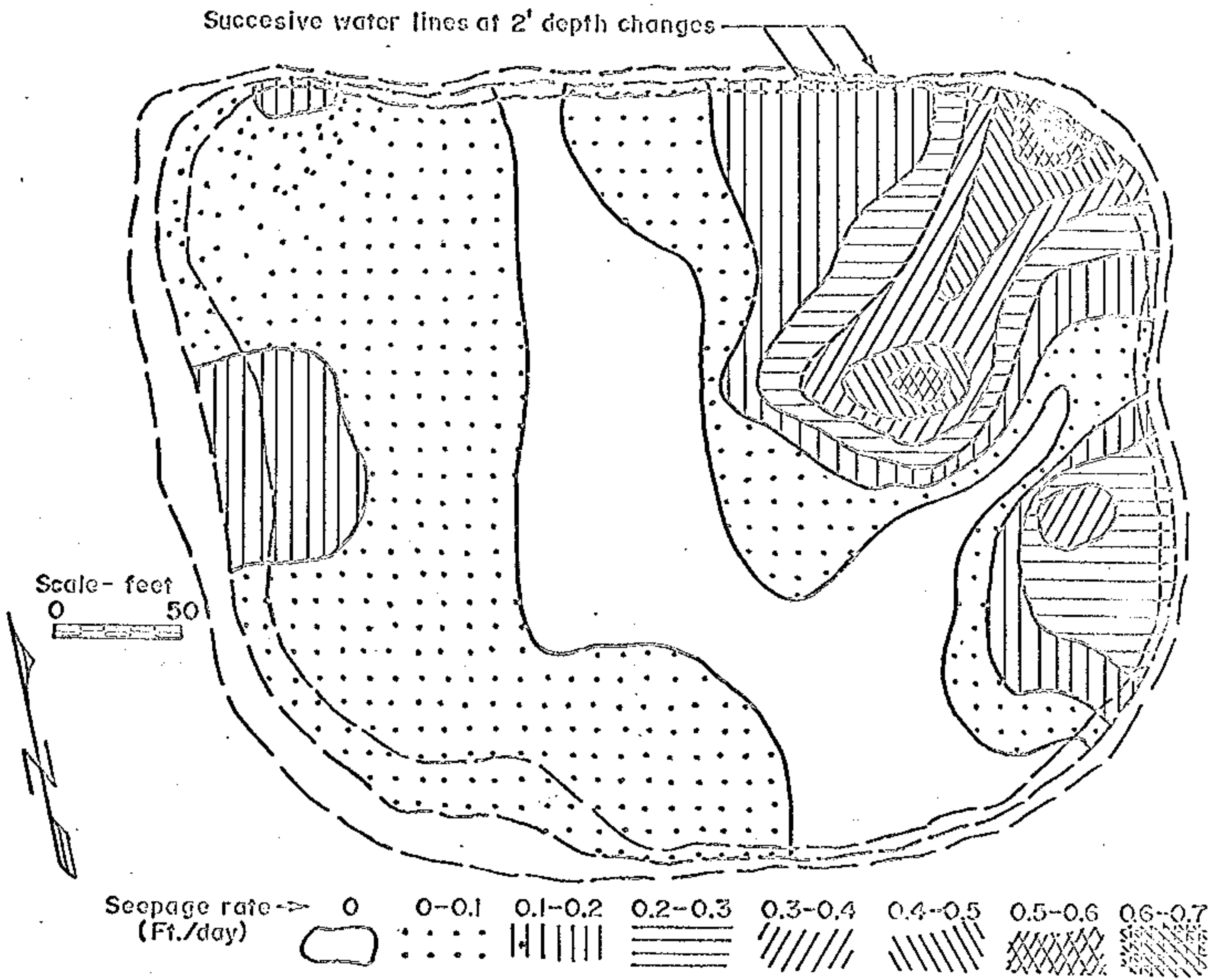

Figure 6. Areas of seepage in a pond near Caldwell, Idaho.